

1 INTEGRATED BI-DIRECTIONAL OPTICAL TRANSCEIVER

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4 CROSS-REFERENCE TO RELATED APPLICATIONS

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6 This application claims the benefit of United States
7 Provisional Application Serial No. 60/412,497, filed September
8 23, 2002.

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11 FIELD OF THE INVENTION

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13 This invention relates to optical transceivers and, more
14 particularly, to packaged optical transceivers.

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17 BACKGROUND OF THE INVENTION

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19 Optical fibers are useful in high-speed data transmission
20 systems. These high-speed systems can include an optical
21 fiber optically coupled to a module which includes a light
22 emitting or light detecting device. A module with a light
23 emitting device is typically referred to as a transmitter

1 module wherein an electrical signal is converted to a light
2 signal which is emitted by the light emitting device and is
3 incident to the optical fiber. A module with a light
4 detecting device is typically referred to as a receiver module
5 wherein an optical signal is converted to an electrical
6 signal.

7

8 It is important to minimize the cost of the components
9 included in fiber optic systems. In the prior art, the high
10 cost of transceivers built with existing technology makes it
11 cost prohibitive to undertake installation of extensive fiber
12 networks with individual connections. Thus, it is highly
13 desirable to provide a cost effective optical package which is
14 capable of transmitting and receiving data in a fiber to a
15 home network.

SUMMARY OF THE INVENTION

The above problems and others are at least partially solved and the above purposes and others realized in a preferred apparatus embodiment consisting of an optical fiber, and a chip-level optical transceiver carried by a bench disposed in a tilted state aligning the chip-level optical transceiver with the optical fiber. Further to this embodiment is a package securing and containing the optical fiber, the bench, and the chip-level optical transceiver carried by the bench. The package includes a support structure securing the fiber, and a header coupled to the support structure, in which the bench is carried by the header in front of the optical fiber. Preferably, the bench and the chip-level optical transceiver carried thereby are hermetically sealed by the package. The chip-level optical transceiver consists of a light emitting device, having an output, for emitting a first wavelength of light along a first optical path, a first photodiode for controlling the output of the light emitting device, a second photodiode having an active region, a lens for receiving the first wavelength of light along the first optical path from the light emitting device and collimating the first wavelength of light to the

1 second photodiode along the first optical path, and the second
2 photodiode for reflecting the first wavelength of light along
3 the first optical path into the optical fiber along a second
4 optical path. The optical fiber is capable of transmitting a
5 second wavelength of light to the second photodiode along the
6 second optical path, and the second photodiode adapted and
7 arranged to permit the second wavelength of light to pass
8 therethrough to the active region thereof for conversion into
9 an electrical signal. The first optical path is coincident to
10 the second optical path, and the first wavelength of light is
11 different from the second wavelength of light.

12

13 In accordance with the principle of the invention,
14 another apparatus embodiment consists of an optical fiber, a
15 header mounted adjacent the optical fiber, and a chip-level
16 optical transceiver supported by a bench carried by the header
17 in a tilted state aligning the chip-level optical transceiver
18 components with the optical fiber. A support structure
19 secures the fiber, and the header is coupled to the support
20 structure. The support structure and the header cooperate to
21 hermetically seal the bench and the chip-level optical
22 transceiver carried thereby. The chip-level optical
23 transceiver consists of a light emitting device, having an

1 output, for emitting a first wavelength of light along a first
2 optical path, a first photodiode for controlling the output of
3 the light emitting device, a second photodiode having an
4 active region, a lens for receiving the first wavelength of
5 light along the first optical path from the light emitting
6 device and collimating the first wavelength of light to the
7 second photodiode along the first optical path, and the second
8 photodiode for reflecting the first wavelength of light along
9 the first optical path into the optical fiber along a second
10 optical path. The optical fiber is capable of transmitting a
11 second wavelength of light to the second photodiode along the
12 second optical path, and the second photodiode adapted and
13 arranged to permit the second wavelength of light to pass
14 therethrough to the active region thereof for conversion into
15 an electrical signal. The first optical path is coincident to
16 the second optical path, and the first wavelength of light is
17 different from the second wavelength of light.

18

19 In accordance with the principle of the invention, still
20 a further apparatus embodiment consists of a package including
21 a header, an optical fiber extending into the package and
22 secured thereby adjacent the header, and a chip-level optical
23 transceiver supported by a bench carried by the header in a

1 tilted state aligning the chip-level optical transceiver
2 components with the optical fiber. The package hermetically
3 seals the bench and the chip-level optical transceiver carried
4 thereby. The chip-level optical transceiver consists of a
5 light emitting device, having an output, for emitting a first
6 wavelength of light along a first optical path, a first
7 photodiode for controlling the output of the light emitting
8 device, a second photodiode having an active region, a lens
9 for receiving the first wavelength of light along the first
10 optical path from the light emitting device and collimating
11 the first wavelength of light to the second photodiode along
12 the first optical path, and the second photodiode for
13 reflecting the first wavelength of light along the first
14 optical path into the optical fiber along a second optical
15 path. The optical fiber is capable of transmitting a second
16 wavelength of light to the second photodiode along the second
17 optical path, and the second photodiode adapted and arranged
18 to permit the second wavelength of light to pass therethrough
19 to the active region thereof for conversion into an electrical
20 signal. The first optical path is coincident to the second
21 optical path, and the first wavelength of light is different
22 from the second wavelength of light.

1 In accordance with the foregoing summary of preferred
2 embodiments, and the ensuing specification, which are intended
3 to be taken together, the invention also contemplates
4 associated apparatus and method embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

Referring to the drawings:

FIG. 1 is a simplified, vertical sectional view of an integrated transceiver package incorporating a tilted bench assembly supporting chip-level optical transceiver components, in accordance with the principle of the invention; and

FIG. 2 is a simplified, vertical sectional view of the tilted bench assembly of FIG. 1 carried by a header and disposed in optical alignment with an optical fiber.

1 DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

2
3 An integrated bi-directional optical transceiver that is
4 capable of transmitting and receiving data in an optical fiber
5 is disclosed, which includes a package that incorporates a
6 header. An optical fiber extends into the package, and is
7 secured thereby adjacent the header. A chip-level optical
8 transceiver is supported by a bench carried by the header in a
9 tilted state aligning the chip-level optical transceiver
10 components with the optical fiber.

11
12 Turning now to the drawings, in which like reference
13 characters indicate corresponding elements throughout the
14 several views, attention is first directed to FIG. 1, in which
15 there is seen a simplified, vertical sectional view of a an
16 integrated bi-directional transceiver package 100
17 incorporating a tilted bench assembly 105 supporting chip-
18 level optical transceiver components, in accordance with the
19 principle of the invention. The chip-level optical components
20 carried by bench assembly 105 are considered part of bench
21 assembly 105. Package 100 incorporates a header 106, which is
22 the underlying support for bench assembly 105. Header 106 has
23 an inner face or surface 109 and an opposing outer face or

1 surface 113. Surfaces 109 and 113 reside in spaced-apart,
2 substantially parallel planes. Header 106 is fashioned of
3 steel that is coated with gold plating of a predetermined
4 thickness, although it can be constructed of another metal or
5 combination of metals and/or metal composites, or from a non-
6 metallic material such as co-fired ceramic, or other material
7 or combination of materials capable of providing support for
8 placement of bench assembly 105 as described below. Bench
9 assembly 105 is carried by header 106, and header 106
10 constitutes the underlying support for bench assembly 105.
11 Header 106 supports leads 112, which extend therethrough
12 between surface 109 and surface 113, as illustrated. Leads
13 112 are fashioned of conductive material, and provide
14 electrical communication between the transceiver components of
15 package 100 and external electrical components. Preferably,
16 leads 112 are gold plated and are separated from header 106 by
17 insulators, such as glass insulators. In a preferred
18 embodiment, package 100 incorporates approximately eight
19 leads. However, less or more can be used, if desired,
20 including even one lead.

21

22 Header 106 supports a recess 110, which is formed therein
23 through surface 109. In accordance with the invention, recess

1 100 defines a ramp 110A, which is oriented at an angle θ (FIG.
2 2) relative to surface 109. Bench assembly 105 is held by
3 recess 110, and is disposed against ramp 110A so as to reside
4 in a tilted state, thus aligning its chip-level optical
5 transceiver components in a tilted state. Ramp 110A is thus
6 formed to receive and hold bench assembly 105, which carries
7 transceiver components operable for emitting a wavelength of
8 light λ_1 along an optical path 220. Bench assembly 105 is
9 described in more detail below in conjunction with FIG. 2.

10

11 In the preferred embodiment disclosed herein, package 100
12 includes a preamplifier 107 attached to surface 109, which is
13 coupled in electrical communication to bench assembly 105 and
14 lead 112. Preamplifier 107, which is an optical component,
15 amplifies electrical signals from bench assembly 105.
16 Preamplifier 107 can be omitted, if desired.

17

18 Package 100 incorporates an attached can structure 104,
19 which overlies surface 109. Can structure 104 is attached to
20 header 106, preferably to surface 109, and cooperates with
21 header 106 to enclose bench assembly 105 and preamplifier 107.
22 Can structure 104 provides hermetic sealing of bench assembly
23 105 and preamplifier 107. Can structure 104 defines opposing

1 openings 114 and 115, in which opening 114 is located
2 proximate surface 109, and opening 115 is formed opposite
3 surface 109 and is adapted and arranged to receive
4 therethrough an optical fiber 101.

5

6 Bench assembly 105 is disposed in recess 110 and against
7 ramp 110A, as previously mentioned, and, in accordance with
8 the invention, is optically aligned with, and thus optically
9 coupled to, fiber 101. The tilt of bench assembly 105 as
10 defined by angle θ , as defined by ramp 110A, is in a range
11 from approximately 5° to 40° relative to surface 109 of header
12 106. In accordance with the invention, fiber 101 is thus
13 optically aligned with bench assembly 105, in which the
14 optical alignment is facilitated by the tilt of bench assembly
15 105 relative to fiber 101.

16

17 Optical fiber 101 extends into package 100, and is
18 operative for transmitting a wavelength of light λ_2 from a
19 remote light source or transmitter. Optical fiber 101 is held
20 in place by package 100, so as to be disposed therein, and
21 through opening 115 of can structure 104, with a flange 103,
22 which is part of package 100. Flange 103 is externally
23 attached to can 104 proximate opening 115, such as by way of a

1 selected adhesive or welding or solder or the like, encircles
2 fiber 101, and supports fiber 101, thus holding it in place.
3 Overlying flange 103 is a ferrule assembly 102, which is also
4 part of package 100. Fiber 101 passes through, and is secured
5 by, ferrule assembly 102. Ferrule assembly 102, flange 103
6 and can structure 104 cooperate as a support structure for
7 fiber 101, in which this defined support structure is attached
8 to header 106. Flange 103 can be considered part of can
9 structure 104, if desired. Because header 106 is attached to
10 can structure 104, header 106 can be considered part of, or
11 otherwise an extension of, can structure 104 and, therefore,
12 part of or otherwise an extension of the support structure as
13 defined herein.

14

15 Package 100 also incorporates an attached strain relief
16 boot 108, which surrounds can structure 104, flange 103, and
17 ferrule assembly 102, and also a portion of fiber 101
18 extending upwardly from ferrule assembly 102. Strain relief
19 boot 108 provides added support to package 100, and inhibits
20 package 100 from becoming fractured or otherwise damaged as a
21 result of turns or thrust abuse. Strain relief boot 108
22 encloses can structure 104, flange 103, ferrule assembly 102,

1 and the portion of fiber 101 extending into and through
2 ferrule assembly 102 to within can structure 104.

3

4 Looking to FIG. 2, bench assembly 105, which functions as
5 a transceiver as previously mentioned, consists of a bench
6 205, which, in accordance with the principle of the invention,
7 supports chip-level optical transceiver components, namely,
8 two photodiodes 201 and 204, a light emitting device 202, and
9 a lens 203. In a further and more particular aspect, the
10 chip-level optical transceiver components of bench assembly
11 105 function as a chip-level optical transceiver. Bench 205
12 is elongate, is generally rectangular in shape, and, for the
13 purpose of orientation in connection with the ensuing
14 discussion, has opposing ends 205A and 205B, and opposing
15 upper and lower surfaces 205C and 205D. Pockets or trenches
16 225, 226, and 227, which are disposed between ends 205A and
17 205B, and are formed into bench 205 through upper surface
18 205C. Trench 225 is V-shaped and is disposed adjacent end
19 205A. Trench 227 is also V-shaped, and is disposed adjacent
20 end 205B. Trench 226 is generally V-shaped, and is disposed
21 between trenches 225 and 226. Trenches 225, 226, and 227, are
22 formed into bench 205, such as by way of etching (e.g., wet or
23 dry etching), cutting, machining, etc. Bench 205 is

1 integrally fashioned, and is constructed of silicon (Si), a
2 low temperature co-fired ceramic, or a similar material or
3 combination of materials that can be etched or otherwise cut
4 to form trenches 225, 226, and 227. Photodiode 201 is carried
5 by trench 225, lens 203 is carried by trench 226, photodiode
6 204 is carried by trench 227, and light emitting device 202 is
7 attached to upper surface 205C between trenches 225 and 226,
8 and between photodiode 201 and lens 203.

9

10 Light emitting device 202 is operable for emitting light
11 at wavelength λ_1 along an optical path 220. Preferably, light
12 emitting device 202 is an edge-emitting emitting semiconductor
13 laser. However, light emitting device 202 can be a face-
14 emitting semiconductor laser, or other desired form of laser-
15 emitting device. Trenches 225, 226, and 227, are aligned on
16 optical path 220.

17

18 Photodiode 201 is held in trench 225 and rests against a
19 major surface 225A of trench 225, and is positioned or
20 otherwise aligned so that it is able to detect light at
21 wavelength λ_1 emitted through end 230 of device 202 along
22 optical path 220. Photodiode 201 controls the output of light
23 emitting device 202, and this arrangement is well known in the

1 art. End 230 of device 202 is directed toward photodiode 201.
2 Lens 203 is held in trench 226, and is positioned to direct,
3 e.g., collimate, light at wavelength λ_1 emitted through end
4 231 of device 202 to photodiode 204. Lens 203 is preferably a
5 ball lens, although those of ordinary skill will appreciate
6 that other lens forms can be used. Photodiode 204 is held in
7 trench 227 and rests against a major surface 227A thereof, and
8 is positioned or otherwise aligned so that it is able to
9 detect light at wavelength λ_1 from lens 203 along optical path
10 220. Photodiode 204 incorporates a dichroic filter 223,
11 which, in the preferred embodiment disclosed herein, consists
12 of an applied dichroic mirror, although it can consist of an
13 applied thin film of dichroic material, if desired. Dichroic
14 filter 223 defines an outer surface 222.

15

16 As previously mentioned, optical fiber 101 transmits a
17 wavelength of light λ_2 , from a light source or transmitter,
18 along optical path 221. Bench assembly 105 and fiber 101 are
19 optically aligned so as to provide a peak optical signal, in
20 which optical path 220 is coincident relative to optical path
21 221. Light at wavelength λ_1 from lens 203 along optical path
22 220 is directed against dichroic filter 223 of photodiode 204,
23 and is reflected therefrom into fiber 101 along optical path

1 221. Light at wavelength λ_2 from optical fiber 101 along
2 optical path 221 is also directed toward dichroic filter 223
3 of photodiode 204, and passes there through to an active
4 region of photodiode 204 and is converted into an electrical
5 signal.

6
7 And so it is to be understood that dichroic filter 223,
8 which is considered part of photodiode 204, is adapted and
9 arranged to reflect wavelength of light λ_1 into fiber 101
10 along optical path 221, and to permit the wavelength of light
11 λ_2 along optical path 221 to pass therethrough photodiode 204
12 to an active region thereof for conversion into an electrical
13 signal. In one embodiment, λ_1 can be 1310 nm and λ_2 can be
14 1550 nm. In another embodiment, λ_1 can be 1550 nm and λ_2 can
15 be 1310 nm. It will be understood that 1310 nm and 1550 nm
16 are wavelengths typically used in optical fiber communication
17 systems. However, it will be understood that other
18 wavelengths could be used, and that the use of 1310 nm and
19 1550 nm in this disclosure is set forth as a matter of example
20 and not by way of limitation.

21

1 Surface 222 is oriented at an angle ϕ relative to optical
2 path 220 by tilting bench assembly 105 at a desired angle,
3 namely, angle θ as provided by ramp 110A, or, in accordance
4 with an alternate embodiment, by choosing an angle γ of
5 surface 227A of trench 227. Hence, light emitting device 202
6 and fiber 101 can be optically aligned by choosing at least
7 one of angles θ , ϕ , and γ . In a preferred embodiment, optical
8 paths 220 and 221 are optically aligned by disposing bench
9 assembly 105 at a desired tilt or angle as defined by angle θ ,
10 in accordance with the principle of the invention.

11

12 Thus, an integrated bi-directional optical transceiver is
13 disclosed, which is capable of transmitting and receiving data
14 in an optical fiber, which can be used in a network and in
15 other ways, namely, as a phase converter in a computer, and in
16 other like applications. A bi-directional optical transceiver
17 constructed in accordance with the principle of the invention
18 is easy to construct and inexpensive, and is capable of
19 providing low cost and high power optical communication in a
20 fiber to a network. Because the transceiver package disclosed
21 herein incorporates a bench to which chip-level optical
22 transceiver components are attached, a transceiver package

1 constructed and arranged in accordance with the principle of
2 the invention is highly compact, and very small, as compared
3 to existing transceiver packages. The transceiver package
4 disclosed herein allows bi-directional communication by using
5 a dichroic filter positioned on a photodiode. The dichroic
6 filter is chosen to allow the transmission of one wavelength
7 of light while allowing the reflection of another wavelength
8 of light.

9
10 The present invention is described above with reference
11 to a preferred embodiment. Those skilled in the art will
12 recognize that changes and modifications may be made in the
13 described embodiment without departing from the nature and
14 scope of the present invention. Various changes and
15 modifications to the embodiment herein chosen for purposes of
16 illustration will readily occur to those skilled in the art.
17 To the extent that such modifications and variations do not
18 depart from the spirit of the invention, they are intended to
19 be included within the scope thereof.

20

21 Having fully described the invention in such clear and
22 concise terms as to enable those skilled in the art to
23 understand and practice the same, the invention claimed is: